

Medical Technology and Procedure Development for MRI guided procedures Andreas Melzer MD, DDS

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Context

Medical Technologies and Medical Devices such as surgical Instruments, interventional probes and implants have an increased value for diagnostic and treatment of diseases. Artificial joint prosthesis, heart valves, pacemaker, neurostimulator and stents are representing a fast growing 20 billion \$ market. Stents are fenestrated expandable tubes that are implanted in artery obstruction to prevent restenosis. The combination of stents and drugs as the “Drug Eluting Stents” had prolonged opening time and reduced the need for reinterventions but it is linked to an increased rate of thrombosis. However all these metallic implants compromise Magnetic Resonance Imaging MRI which as a non invasive technique becoming the most important imaging modalities for cardiovascular, cancer, and musculoskeletal pathology. We have developed a unique technology to implement a resonant circuitry that functions as an antenna for inductive coupling of the implant and MRI scanner significantly improving imaging. .

Aims

Successful research and development of medical technologies and devices require an open interdisciplinary platform with particular focus on clinical needs and evidence based medicine. The Universities of Dundee and St. Andrews have founded the Institute of Medical Science and Technologies IMSaT with the purpose of strengthen various existing excellent projects on both sides.

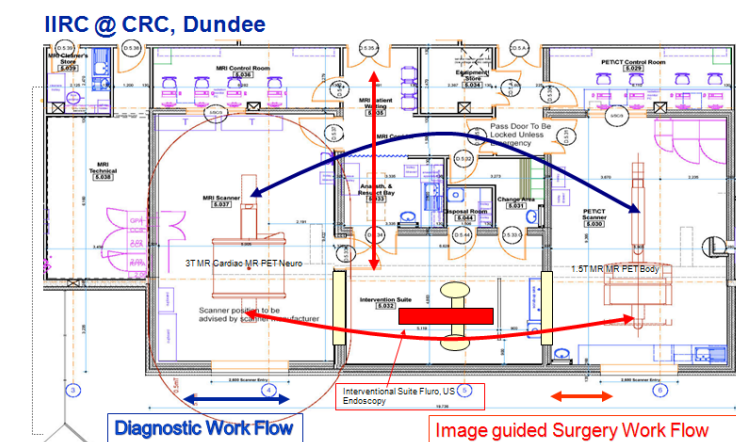
To support clinical use IMSaT will be closely linked to Ninewells Hospital and the new Clinical Research Center CRC. The combination of diagnostic imaging with therapeutic imaging such as interventional MRI, Ultrasound, SonoOptics sonoporation or photoporation, as well as intelligent MRI safe implants, tissue engineering and image guided robotics is about to forming the current program of research at IMSaT www.imsat.co.uk .

Clinical Research

IMSaT's goal is a greater appreciation of the commercialization, clinical needs, efficacy, efficiency and economics to enhance translation of our results into medical products providing sustained impact into the healthcare system.

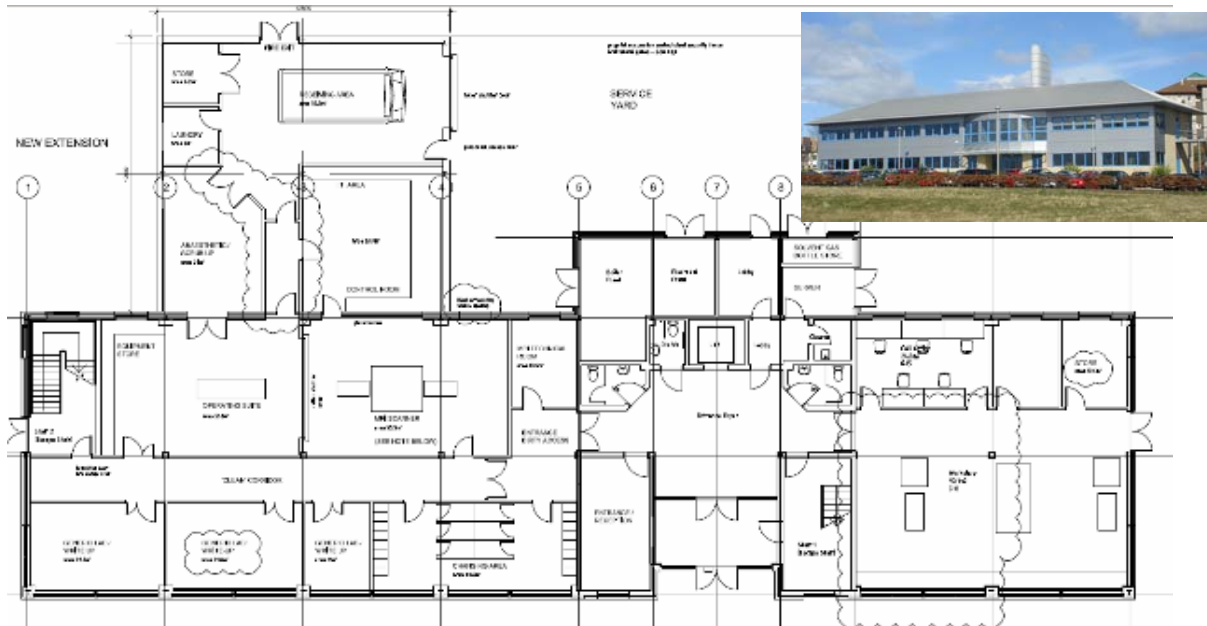
IMSaT's vision of future medical technologies is the marriage with biotechnology and pharmaceuticals. Recent advances in imaging reveal information even to the cellular and molecular level opening new challenging areas of research towards targeted and device based drug delivery which can be explored in cooperation with the School of Life Sciences and the TMRC Scottish Translational Medical Research Center. The new Clinical Research Center is equipped with a 3 Tesla MRI and PET CT connected to an interventional suite one of the first setups of this kind. Key joint projects are in the area of early detection for cardiovascular disease CHF and Vulnerable Plaque imaging, Cancer detection and staging, Neuro-behavioral imaging, including the clear target of integrated interventional procedures.

The R&D network of IMSaT, CRC, TMRC, life science represent an uniquely effective



pipeline from science to clinical practice because these activities are integrated with the Ninewells university hospital and the collaboration with the other three major universities Aberdeen, Edinburgh and Glasgow under the direct support and co funding of NHS.

IMSaT will be located in proximity to Ninewells Hospital and Medical School in the new Wilson House a two story building with 10.000 sqf lab space including fully equipped workshop with CAD CAM, Laser cutting for instruments and implant production, tissue lab, imaging and photonics lab, and interventional MRI suite attached to and Interventional Operating Suite.



Workflow process analysis, modulation and simulation for optimal systems integration and training courses will be major projects for implementation of MRI guided procedures.

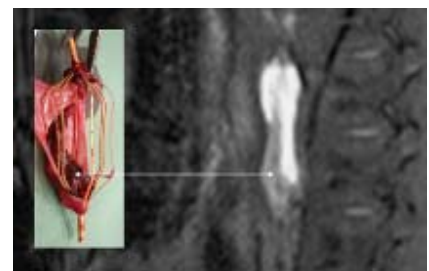
MRI guided interventions R&D program IMSaT and IIRC

Andreas Melzer in Collaboration with Biophan Europe

Due to the improved signal to noise spatial as well as temporal resolution of 1.5 /3 T MR guided vascular procedures are of significant interest for device and implant development at IMSaT. The following program is supported by grants and corporate research.

Vascular Implants

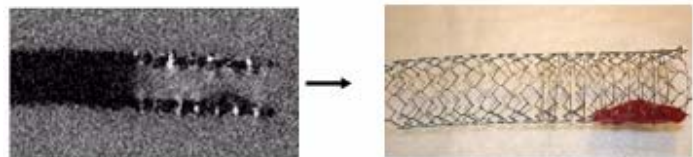
MRI visible stents for peripheral and coronary implantation and **Vena Cava Filter** have been realized through the use of resonant circuits integrated with the implant structure.



MR Stents

Two types of stents are currently in preclinical trials.

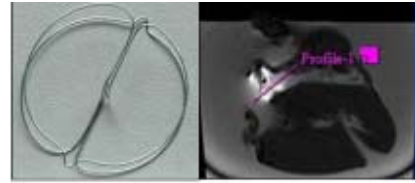
1. Balloon expanding resonant stent currently undergoes test in a chronic trial at Dept of Cardiology, University Essen.
2. Self expanding Nitinol peripheral stent is currently been developed and evaluated with support of Boston Scientific.



The resonant circuit overcomes the shielding of the standard stent increases signal (x4) and signal to noise (S/N) and contrast without contrast agents

Structural Heart Disease

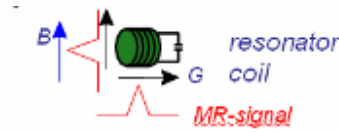
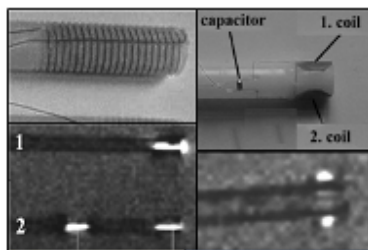
Further application are MR resonant occluder devices for closure of cardio septal defects such as PFO, ASD and VSD and occlusion of patent Ductus Botally and sealing of the left atrial appendage.



MRI of a resonant occluder in a porcine heart

MR visible Guide Wire and Catheter

Passively MRI compatible guide wires have been developed at our own group and at University Basel. Resonant marker have been made for catheters and delivery systems and will be further developed at IMSaT in collaboration with the microsystems groups at University Dundee. Based on the work M. Went at CASE Western in Cleveland tracking techniques can be implemented for image localization the passive resonant marker. Sufficient radiopacity ensures dual purpose use under XRay.

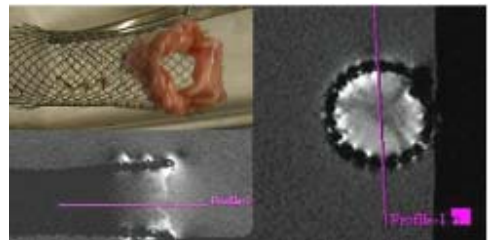


- MR Guided Catheterization
- MR Tiptracking.
- MR endovascular imaging

Once the visualization and localization of interventional devices is optimized for 1.5/3 Tesla other MRI guided cardiac procedures can be realized e.g. myocardial ablation, stem cell injection, revascularization and coronary stent implantation.

MR guided Heart Valve Repair

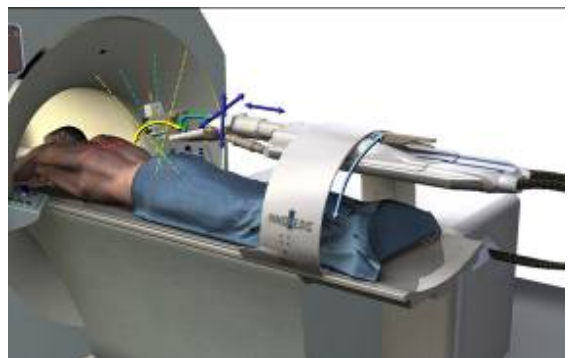
Although Dundee does not provide cardiac surgery IMSaT will further develop MR resonant percutaneously implantable heart valves and delivery systems. Initial application has been done in collaboration with the NHLBI at NIH, Bethesda. A self expanding resonant aortic heart valve was implanted through a transapical approach. By using the first fully MRI compatible robotic system Innomotion the implantation can be facilitated.



MRI resonant selfexpanding heart valve

MRI guided robotic assisted percutaneous interventions

The robotic system Innomotion has been developed in collaboration with Innomedic, GMBH Herxheim as the worlds fist MRI and CT compatible robotic system with CE mark. Current clinical studies on MRI guided liver, prostate and bone biopsy, sciatic pain treatment reveal significant improvement of MRI guided percutaneous interventions. INNOMOTION will be further developed at IMSaT for use in 1.5/3 T with specific focus on interventional oncology and neuro interventional procedures and MRI guided surgery.



MRI guided breast biopsy, tumour ablation, abscess drainage can be first clinical studies.



43 y. male 65 kg, 2 year history of recurrent sciatic and back pain only, 2 treatments of facet joints with 40 mg Triamcinolone and 5 ml Mepivacain = 3 month pain free.